

Vetiver Research, Development and Applications in Thailand*

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Abstract

Vetiver R&D works recently conducted in Thailand have been briefly described, viz. improvement of forest ecosystem, carbon sequestration, stabilization of highway slopes, characterization of native vetiver ecotypes, selection of native vetiver ecotypes for forest area, and phytoremediation by various methods. In addition, vetiver applications have also been described, viz. rehabilitation of deteriorated environment, soil conservation in sloping agricultural areas, contests on vetiver planting, vetiver-planting promotion, and vetiver handicraft design, setup of vetiver's fanatics networks, establishment of vetiver banks, and architectural utilization of vetiver board.

Keywords: Forest ecosystem, carbon sequestration, characterization, phytoremediation, soil stabilization, vetiver contests, vetiver's fanatics networks, vetiver banks.

1. Introduction

Vetiver has been used for soil and water conservation as well as many agricultural and non-agricultural applications in Thailand for almost 20 years after its merit has been realized through the initiation of His Majesty the King. The present paper describes the R&D works on vetiver as well as its application recently accomplished in Thailand.

2. Research and Development

His Majesty the King was the one who suggested that vetiver could well be the answer to stabilizing Thailand's fast eroding lands while reducing excess runoff and related problems. In his several messages concerning vetiver, he asked the officers who had an audience with him to start doing research and development on vetiver. An attempt to compile

all the R&D works during the past few years has met with difficulty in that there are so many agencies in Thailand which conducted R&D but did not publicize their works. Thus only a fraction of the works have been accumulated and presented below.

2.1 Improvement of Forest Ecosystem

The study on the role of vetiver on improving the forest ecosystem of dry dipterocarp and mixed deciduous forests revealed that within just two years (2007-09), vetiver planted in contour of 2m vertical interval has considerably improved the moisture content of surface soil which helps in reducing the risk of forest fire. Soil structure of the dry dipterocarp forest slowly developed, with a total density of 1.28-1.97 megagram/m³, while that of mixed deciduous forest was 0.92-1.39 megagram/m³. The amount of organic matter of the dry dipterocarp forest was quite low, at 17.0-18.2 g/kg of soil while that of mixed deciduous forest was at 11.2-37.1 g/kg of soil. No significant difference was found in plant population as well as in meteorological development. However, meteorological characters were found to have positive

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correlation with the climate. Average humidity of dry dipterocarp forest has increased only a little, at 8.37-10.19% by volume, while in mixed deciduous forest was at 7.70-10.54% (Anon. 2009d).

2.2 Carbon Sequestration

In order to compare the potential of vetiver in carbon sequestration, Thammathavorn and Khanema (2010) employed 11 ecotypes of Thai native vetiver in the experiment by sampling the specimens when vetiver plants were 3 years old. Soil samples were analysed for dry weight, total carbon and nitrogen in the roots, stems and leaves. It was found that 'Loei' ecotype had the highest average weight while 'Ratchaburi' ecotype had the lowest. Carbon and nitrogen were all accumulated in the root, stem and leaves, respectively. 'Ratchaburi' ecotype has increased carbon at the highest rate of 11 tons/ha/year, while the lowest was the 'Loei' ecotype at 4 tons/ha/year. The anatomical study revealed that all 11 ecotypes have distinct characteristics of hydrophytes, i.e., having large cellular pores that should relate to the storage of water and air, as well as circulating water and air in the vetiver leaf. All 11 ecotypes had higher rate of carbon deposition into the soil more than the areas planted with *Acacia mangium*, tropical grassland, perennial ryegrass, wheat, barley and oat. Vetiver can sequester higher amount of carbon in the areas having high concentration of clay particles.

2.3 Stabilization of Highway Slopes

Vetiver system was successfully applied in stabilizing eroding and collapsed highway slopes. The success of the application depends on adopting optimum planting techniques which include: (1) suitable planting materials (2) soil fertility improvement, (3) planting during suitable period, (4) planting pattern based on degree of severity, (5) maintenance after planting, (6) effect of site area such as land surface, slope inclination, effect of shading, and (7) inter-planting with N-fixing cover plant (*Arachnis pinto*) to provide N

fertilizer to save maintenance cost. Such an application also prevents shallow-seated failure and earth-flows in saturated soils as well. Vetiver system has been successfully applied in the following highway situations: (1) backslopes, (2) sideslopes, (3) stream banks along the highway, (4) ditch linings, (5) shoulder slopes, (6) gabion walls, and (7) drainage structures (Sanguankaeo *et al.* 2010).

2.4 Characterization of Native Vetiver Ecotypes

Characterization has been made on 27 ecotypes of native vetiver based on 31 morphological characters. A total of 14 distinct varieties have been identified, namely 'Chiang Rai', 'Kanchanaburi', 'Kamphaeng Phet 1', 'Roi Et', 'Phitsanulok', 'Nakhon Sawan', 'Trang 1', 'Trang 2', 'Chaiyaphum', 'Songkhla 2', 'Saraburi 1', 'Saraburi 2', and 'Loei'. The remaining 13 ecotypes will be characterized in 2010 while five other ecotypes exhibited wide variations. Among the 27 varieties which have been characterized, 14 have been evaluated in 2009 while the remaining 13 will be evaluated in 2010 (LDD 2010).

2.5 Selection of Native Vetiver Ecotypes for Forest Area

The stress test on shade tolerance of native vetiver revealed that four ecotypes were able to tolerate shade equally well. These are HK-SD-R 1; HK-SD-R 2; HK-SD-R 3 and HK-SD-R 4. The test on drought tolerance resulted in three ecotypes, on water logging - one ecotype, and on alternate dry and wet conditions - three ecotypes. All other characters remain unchanged. They were multiplied for use in future experiments and have met with difficulty in order to produce enough planting material for the experiment such that propagation by seeds was attempted. The seeds had 55-75% germination rate, with poor initial growth but with good survival rate. They are now having good growth and shall be used to produce seeds for future experiment (Anon. 2009c).

2.6 Phytoremediation

Vetiver has great potential to rehabilitate contaminated or intoxicated soil and water because it can tolerate high concentration of pollutants and heavy metals. Many authors have demonstrated the successful applications in using vetiver as a remedy for removing pollutants and heavy metals in contaminated or intoxicated soil and water in Thailand. Among these are:

2.6.1 Cleanup of Arsenic-Contaminated Water: John *et al.* (2008) conducted an experiment to clean up arsenic-contaminated pond water in Nakhon Si Thammarat, Southern Thailand. Planted pond consisted of 'red earth' - rice husks and gravel - planted with vetiver and *Colocasia esculenta*, then flushed twice a day, approx. 20 cm high. The result indicated that a pond with a volume of 9 m³ and a throughput of 1.5 m³ water daily was able to reduce an arsenic content of 800 to less than 10 µg/L at the outlet, which is in accordance with the WHO value. This system has an operational safety of one year at least. The operation and maintenance of the planted soil filters are quite simple and fulfil all expectations of a simple cleaning process. No chemicals are needed to be added to the water. The energy demand is low especially by using a natural gradient for the arrangement and construction of the ponds. The cleaning process meets all requirements for an effective, economical and sustainable arsenic water treatment system.

2.6.2 Domestic Wastewater Treatment: Boonsoong (2008) planted vetiver using "floating platform techniques" to treat domestic wastewater. The study was divided into three phases of 8 weeks each, using 7-, 5- and 3-d hydraulic retention time (HRT), respectively. Two different control parameters including two vetiver ecotypes and no plant as control, and two wastewater strengths - high (HCW) and low (LCW) concentration wastewater - were examined. The average HCW influent contained 90.12-94.88 mg/L BOD, 41.025-52.806 mg/L TN (total nitrogen) and 5.892-6.657 mg/L TP (total phosphorus), whereas the average of LWC were 44.28-58.92, 34.731-42.144 and 4.838-5.482 mg/L, respectively.

The results indicated that the treatment efficiencies of different HRT and wastewater concentrations were significantly different. The 7-d HRT showed the highest treatment efficiency. The treatment efficiencies of BOD, TKN and TP in HCW were higher than in LCW, with the average of 90.5-91.5, 61.0-62.5 and 17.8-35.9%, respectively. The treatment efficiencies of 'Songkhla-3' and 'Surat Thani' ecotypes were not significantly different. However, the treatment efficiencies of BOD and TP of 'Surat Thani' were slightly higher than 'Songkhla-3'. The biomass increment of 'Surat Thani' in LCW was higher than in HCW, whereas Songkhla-3 showed the opposite trend. Thus, the overall results suggested that the optimal condition of this technique should be designed at 7-d HRT and planted with 'Surat Thani' ecotype. However, if wastewater contained high nutrients, 'Songkhla-3' ecotype should be planted.

2.6.3 Removal of Heavy Metals from Industrial Water: Roongtanakiat *et al.* (2007) investigated the ability of vetiver to uptake heavy metals from industrial wastewater. Three vetiver ecotypes, 'Kamphaeng Phet-2', 'Sri Lanka' and 'Surat Thani', were cultured in 4 kinds of industrial wastewater, viz. milk factory (W1), battery manufacturing plant (W2), electric lamp plant (W3), and ink manufacturing facility (W4). It was found that vetiver could grow well in these wastewaters. However, the concentration of heavy metals in wastewater played an important role in vetiver growth. In W1, it grew the best while in W4 the least, as it was contaminated with Mn, Fe, and Cu. The three vetiver ecotypes absorbed Fe>Mn>Zn>Cu>Pb, concentrating more Pb in the roots than in the shoots. Total uptake of Fe and Zn were highest in vetiver grown in W1, while the highest concentration of Pb had the highest total Pb uptake. Vetiver grown in W1 had the highest Mn, Fe, Zn and Pb removal efficiencies of 33.72, 27.63, 52.73 and 8.94%, respectively, whereas those in W4 had an efficiency of up to 87.5% Cu removal from the wastewater, although it showed a symptom of Cu toxicity on root growth. 'Sri Lanka' ecotype had the best growth and the highest heavy metal removal efficiencies.

2.6.4 Rehabilitation of Iron Mines:

Roongtanakiat *et al.* (2008) conducted a greenhouse experiment to evaluate the effects of soil amendments on growth, performance and the accumulation of primary nutrients and heavy metals (Fe, Zn, Mn, and Cu) in vetiver. Plantlets of 'Ratchaburi' ecotype were planted on iron ore tailings amended with compost and chelating agents (EDTA and DPTA). It was found that iron ore tailings contained high concentrations of heavy metals and low contents of primary nutrients and organic matter. Amending with chelating agents could increase Cu translocation. The average mean translocation factors of Mn, Fe, Zn and Cu were 0.86, 0.71, 0.69 and 0.55, respectively. It was concluded that vetiver is a potential plant for phytostabilization and rehabilitation of iron ore mines.

2.6.5 Improvement of Phytoremediation

Efficiency: Roongtanakiat *et al.* (2009) grew 'Ratchaburi' vetiver ecotype in soil uncontaminated by heavy metals and in zinc mine soil amended with compost and chelating agents. It was found that Zn in the mine soil inhibited vetiver growth as well as causing leaf chlorosis. The compost and chelating agents did not affect Mn and Zn translocation but could elevate Fe and Cu translocation

2.6.6 Heavy Metal Decontamination:

Vetiver is highly tolerant to heavy metals. However, an extremely high concentration of heavy metals could inhibit the growth of vetiver as shown by Roongtanakiat (2009) who did an experiment by treating vetiver with 100% leachate and found that at 80-85 days after planting, all plants died. Research works on the use of vetiver for heavy metal decontamination have been compiled by Roongtanakiat (2009). These are related to ecotypes and growth performance, fertilizer and soil amendments, and translocation of heavy metals in vetiver. 'Kamphaeng Phet-2' ecotype of vetiver was found to be the best as exhibited by the highest plant height and shoot dry weight grown in zinc mine area, while 'Kamphaeng Phet-2' and 'Sri Lanka' ecotypes had significantly high plant height and total dry weight than 'Surat Thani' ecotype when grown

in industrial wastewater (Roongtanakiat *et al.* 2007). Amending iron ore tailings with compost and chelating agents could improve vetiver growth and heavy metal uptakes (Roongtanakiat *et al.* 2009). Vetiver root could accumulate higher heavy metal concentrations than shoot (Roongtanakiat *et al.* 2007).

2.6.7 Uranium Absorption:

Roongtanakiat *et al.* (2010) compared the ability of sunflower, vetiver and purple guinea grass to absorb uranium from radioactive yellow-cake solution. Using an image plate technique, beta and gamma rays from uranium daughter nuclides were used to stimulate image plate phosphor to determine the distribution of uranium in plants. It was found that all three plants could accumulate uranium in their roots better than in shoots. However, sunflower could absorb uranium in both solution and sand culture systems better than purple guinea grass while vetiver had the least absorption. Moreover, sunflower absorbed higher quantities of uranium as the growing time increased. At pH 4, yellow-cake solution facilitated better uranium absorption than at pH 7; however, growth of all plants was found to be better at pH 7.

3. Applications

3.1 Rehabilitation of Deteriorated Environment

The Land Development Department (LDD 2010) launched a project on the campaign of planting vetiver to rehabilitate the deteriorated environment on an annual basis since 1993. Various activities which were conducted were: (i) production of slips to be planted in target areas, (ii) production of slips for free distribution to interested individuals, (iii) encouraging the schools to plant vetiver, and (iv) a national wide campaign to plant vetiver to mark the auspicious occasion of Her Majesty the Queen's Birthday Anniversaries (12 August). The results obtained can be summarized as followed: (1) total slips produced: 1,752 millions, (2) area planted: 700,000 ha. From 2006 onwards, more vigorous nationwide campaign on planting of

vetiver has been made. For example, in 2006, with the budget of Baht 400.5 million (*ca.* US\$ 12 million), the amount of slips propagated was 300 millions while the area planted was 120,000 ha.

3.2 Soil Conservation in Sloping Agricultural Areas

Limthong (2010) is of opinion that soil and water conservation measure play an important role in preventing soil loss and erosion in slopping agricultural areas. In Northern Thailand, corn plantation across the slope caused a soil loss of 5.19-7.81 tons/ha, and ploughing and planting corn across slope could decrease soil loss around 33.6%. On sloping areas, vetiver strip with a VI of 1.5m could decrease soil loss of 4.81 tons/ha. Single row of the vetiver strips gave higher number of shooting and size of clumping than double row strips. At 10 cm spacing, the amount of soil loss was the lowest. In the second year however, dense strip of vetiver planted in double rows could reduce soil erosion, especially in combination with leguminous hedge, with 50-90% reduction while the yield of corn has increased 15-30%. In the eastern part of Thailand the corn fields with vetiver/peanut strips the amount of soil loss amounted to 4.78 tons/ha as compared to 24.4 tons/ha in the control plot. Vetiver hedgerow significantly decreased soil loss up to 82%. In the lowland areas of the Central region the conventional practice has the highest soil loss 2.25 ton/ha as compared to 1.16 tons/ha with vetiver hedgerow and 0.91 tons/ha with terrace plots. The highest of corn yield was 3.56 kg/ha in terrace plots, and slightly decreased to 3.29 kg/ha with vetiver strips. Within 1 ½ years the vetiver strips have turned into ditch because the sediment accumulated in front of the hedge-rows.

3.3 Soil Stabilization

The contest was a collaborative effort by the Coca-Cola Foundation, the National Council on Social Welfare of Thailand, the Hydro and Agro Informatics Institute, the Royal Irrigation Department, the Ministry of

Education, and the Office of the Royal Development Projects Board (Anon. 2008b). Its aims were to provide incentive to the students and to educate students on, and raise their awareness of, sustainable water management and conservation. The final round was held at Khao Hin Son Development Study Centre in Chachoengsao Province, from 8-10 October 2008, and 80 students from four winning schools in each region took part. Students from Huai Yot School in Trang Province presented a project aimed to protect two valuable reservoirs near the school, in which during the rainy season, heavy rains usually collapse the reservoirs' banks and reduce the water level. The water body was also contaminated with garbage and rotten leaves. The students planted vetiver grass on the reservoirs' banks, using vetiver's deep thick roots to stabilize the soil and prevent it from collapsing. Their project won the first prize and received a trophy donated by His Majesty the King.

3.4 Contests on Vetiver Planting, Vetiver-Planting Promotion, and Vetiver Handicraft Design

The Chaipattana Foundation, the Office of the Royal Development Projects Board, the Land Development Department and PTT Public Company Limited (PTT Plc.) have jointly organized contests aiming at inspiring the public to plant and use vetiver to conserve soil and water. The contests have been organized annually from 2006 up to the present to stimulate the growers to do a better job in planting vetiver (Anon. 2007, 2008a, 2009a and 2010). The contests were divided into 3 categories: planting; planting promotion and product design and/or new innovations from vetiver leaves. The experts on vetiver, agriculture, environment and product designs together with the regional committees, and the sub-committee on product design on vetiver leaves were members of the judging panel. The winners of the three categories received the trophies donated by His Majesty the King, and price money and certificates.

3.5 Setup of Vetiver's Fanatics Networks

Through the initiation of the PTT Plc., the Networks of Vetiver's Fanatics have been established throughout the country in 5 regions, viz., the North, the Central, the South, the East, and the Northeast (Anon. 2010). These networks are the assemblage of the people who dedicate their time to work for the expansion of the vetiver activities within their regions. After operating for a while, the National Network was formed consisting of 2-3 members from each region as the officers. The Committee requested the ORDPB, the LDD, and the PTT Plc. to be their advisors of both the regional and the national networks. The activities of the Networks have been expanded in all administrative levels, viz. the community, the sub-district, the district, the province, all the way to the national level. It is hoped that in the future, the Network will link with similar networks of other countries in the Region. They are determined to develop their own areas as the "Center for Complete Cycle of the Vetiver Activities" in order to be the learning centre and expansion on the use of vetiver, from its germplasm collection, its use in soil and water conservation, soil fertility enrichment, agricultural application, vetiver leaf handicraft-making for use in the households and for selling to the markets to supplement their income, all the way to data compilation, community research as the database in order to be used in their communities and with the potential to develop human resources as the experts on vetiver at the local level in both the theory and the practice. Each member has vowed the pledge to be a part in helping His Majesty's pioneering work on vetiver.

3.6 Establishment of Vetiver Banks

Several non-conventional agriculture-related banks have previously been set up in Thailand; the main difference between these banks and the conventional monetary bank is that the former are non-profit and non-monetary in nature. Farmer can draw the item they want from the bank when needed and return it with interest to the bank at a later date

when the farmer has in his possession the item that he has produced/ multiplied. Through the contests on "Vetiver Planting" and "Vetiver-Planting Promotion" organized by the PTT Plc., three vetiver banks were established in 2009 by: (i) Mr. Thongdee Inta, Pratu Pa Sub-district, Mueang District, Lamphun Province; (ii) Mr. Pakpum Poya, Ping Kong Sub-district, Chiang Dao District, Chiang Mai Province; and (iii) Ban Sang Housewife Group, Khi Lek Sub-district, Mae Rim District, Chiang Mai Province (Anon. 2009a).. In the case of Mr. Thongdee Inta who won the PTT's Vetiver Planting Contest, when the neighbours observed his vetiver provided several benefits to his farm, they came and requested for the slips of vetiver for planting on their farms. Instead of giving them free-of-charge, he loaned the slips from his 'Vetiver Bank' to them on condition that the borrowers have to return the same amount of slips to the Bank plus the interest, i.e., an extra amount of slips so that he could loan them to other farmers. The same principle hold for the vetiver banks of Mr. Pakpum Poya and the Ban Sang Housewife Group both of whom won the PTT's Vetiver-Planting Promotion (Anon. 2009a).

3.7 Architectural Utilization of Vetiver Board

The Association of Siamese Architects decided to build its new centre in order to support and provide service to the users. It is located on the 5th Floor of the Siam Discovery Centre in Bangkok. The designer decided to use domestically manufactured materials in order to decrease the cost in transportation and raw materials. The creation of design from environmentally manufactured materials stimulated the demand of the market for the use of alternative materials. The actual structure was assembled from vetiver board (VB) and rubber inserted with wood to enhance the structure's durability and strength. The VB covered the inner structure, giving the exterior of different visual effect. It held the quality in its stiffness and durability, giving the exterior a different visual effect. The manufacturing process of VB was done by cutting the grass

and spreading it out to dry in the sun for 2-3 days, then pressing it into boards. A protective coating of water-based lacquers was applied to the VB to prevent the effects of humidity and staining. This also helped to preserve the surface. In addition to the walls, ceiling and floors of the rooms, VB has also been used in making furniture such as cupboard, tables and chairs (Anon. 2009b).

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